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ABSTRACT

Educational institutions, particularly universities, are facing increasing financial pressures, doubts about their relevance, continuing student violence, over-crowding, and the chaos of a knowledge explosion. These interrelated dynamic problems result from the way the educational system is organized and operated. The system's common ways of dealing with such problems often aggravate, not resolve, the conditions. A preliminary industrial dynamics analysis of the educational system suggests that redirected research programs focus on lifelong individual self-teaching, and charges that cover costs may in time eliminate these current educational problems. Such changes may also encourage greater individual development and prevent educational obsolescence. (Author)

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THE DYNAMICS OF EDUCATIONAL INSTITUTIONS

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Summary

Educational institutions, particularly universities, are facing increasing financial pressures, doubts about their relevance, continuing student violence, over-crowding, and the chaos of a knowledge explosion. These interrelated dynamic problems result from the way the educational system is organized and operated. The system's common ways of dealing with such problems often aggravate, not resolve, the conditions. A preliminary industrial dynamics analysis of the educational system suggests that redirected research programs, focus on lifelong individual self-teaching, and charges that cover costs may in time eliminate these current educational problems. Such changes may also encourage greater individual development and prevent educational obsolescence.

Introduction

Educational institutions at all levels are encountering growing student unrest, costs that are rising faster than revenues, a widening gap between desired and actual quality of instruction, and rapidly increasing student bodies. A rising uncertainty about education's relevance in and to today's society and a knowledge base that is building up too quickly for recent additions to be understood, coordinated, and used effectively also contribute to the distress. These are not isolated, independent, short term problems produced at random by external forces. Rather, they are created as a natural consequence of the way the educational system is organized and directed. The forces that cause the problems are interrelated, rational, systematic, and long-term. Therefore, the problems can be expected to persist and intensify until either their causes are understood and appropriate changes are made or until the system disintegrates from the resulting pressures.

Ordinarily these problems are studied separately. Only a small part of the over-all system is described and analyzed in each case. Solutions, if any, are proposed for one problem without an evaluation of their effects on other problems. The purpose of this paper is to illustrate a perspective and an analysis procedure for the total education system. It focuses on the interacting forces that create the problems. Insight is provided into ways of beneficially modifying the system as a whole.

The philosophy and methodology of industrial dynamics are used to identify and analyse what appear to be the major feedback control loops. A mathematical model of the educational system is described and its performance is simulated on a large scale computer. Since this is a very early stage in this research, the model and conclusions are presented only as examples of the kinds of loops and solutions that may in time be accepted as the basis for system modification.

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Education's Adaptation to Change

Education's objective is to preserve and communicate socially useful knowledge, skills, and attitudes to those who require or desire them. When the quantity and nature of knowledge and skills remain limited and constant, the subject matter and structure of educational institutions are clear, effective, and understood by society. However, institutional structures that evolve under such static conditions are inappropriate to handle the demands and uncertainties caused by a rapidly changing knowledge and attitude base. Furthermore, the adjustments that are made within the structure to try to cope with the changing situations often intensify, rather than solve, the problems.

Expansion of Research

One form of coping with uncertainty, educational obsolescence, and financial deterioration involves the shifting of staff competence and attention from teaching to research. The research is supposed to clarify what it is important to teach, to prolong the usefulness of an education, and to ease financial pressures by bringing in outside funds. However, since the problems result in one way or another from rapidly increasing knowledge, any policy, such as the expansion of research, that accelerates the knowledge increase cannot be expected to solve the problems. Yet once research is started there are several powerful reinforcing feedback loops that perpetrate and increase it.

Student Involvement

A second type of adaptation involves institution-initiated involvement of students in education's administrative activities and the granting of student demands. Rather than leading to student satisfaction, this frequently leads to more demands and greater student militancy. The students' unrest, demands, and violence are their way of coping with their frustrations and uncertainties in a complex, rapidly changing world which they do not understand and cannot control. As students get more involved in the realities of the educational system's structure, they do not find the certainty, security and answers they so badly need in the institutions that are supposed to provide them. Instead they find confusion, uncertainty, and arbitrary power. This reinforces the already-existing frustration and results in more coping actions -- demands and violence. Increased authoritarianism and control by educational institutions also produces deteriorating student-institution relations because this also fails to resolve the students' uncertainty and frustration.

Economic Austerity

Finally, as educational costs rise, universities are reluctant to increase student charges

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correspondingly. Such an increase might deny needed education to the poor, create a materialistic, rather than scholarly, image, and perhaps provoke greater student violence. Added financial pressures arise when the institutions must absorb some of the costs. More outside research funding is sought and internal austerity is practiced. The student-teacher ratio is permitted to rise slowly and new facility expenditures are postponed. The quality of education, relative to what it could and should be, deteriorates for all students. The research produces knowledge which necessitates added investment in facilities and staff. Thus, a policy intended to provide an education to more people has the effect of lowering the quality of education for all, damaging the system's financial condition and providing an education to many who may not want or need it.[4]

Research and Knowledge Expansion

Among the major forces in the educational system are a series of positive feedback loops which force continued and intensified concentration on research. Research is needed (1) to resolve uncertainties and postpone obsolescence caused by previous research, (2) to achieve or maintain competitive advantages, (3) to obtain funds to meet costs caused partly by previous research, and (4) to provide tasks for a research-oriented staff. Negative loops that limit research growth arise as (1) student unrest caused by the uncertainties of rapid change restrains research budgets[7], (2) undesirable by-products of knowledge expansion are recognized and cause resistance to continued research, and (3) increasing research concentration eventually threatens teaching efficiency and other academic functions. A limitation of research is necessary to preserve the educational character of the institution.

Uncertainty Resolution and Obsolescence Postponement

As new knowledge is created, old knowledge is disproved or no longer used. People who learned the old knowledge are no longer needed unless they have somehow also learned the new. Therefore, an education, particularly a technical education, becomes obsolete. The length of time between graduation and the time a significant fraction of one's knowledge must be relearned becomes shorter the faster knowledge increases.

From a school's point of view the likelihood of prolonging the usefulness of an education is related to the timeliness of the knowledge. Therefore, the most recent advances are taught and research is done to discover new knowledge because it will be useful longer than existing knowledge. This works to a student's advantage while he is in school. However, as soon as he finishes, continued research creates knowledge to which he has limited access and renders obsolete the knowledge he has. Therefore, the continuing research done by academic institutions prepares students better, but makes a completed education obsolete sooner. The obsolescence the academic research helps to create requires that more research be done. Figure 1 is a diagram of this feedback loop. An arrow from variable A to variable B means that variable A influences variable B after a time delay.

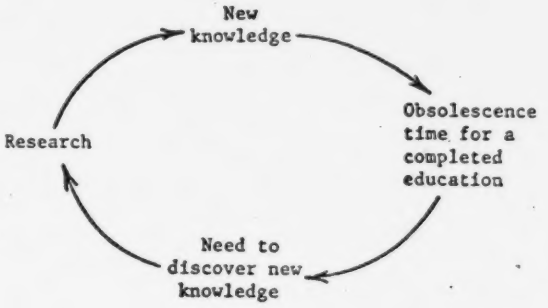

Figure 1. Knowledge regeneration caused by educational obsolescence.

An increase in knowledge would intuitively be expected to lead to an increase in the clarity and certainty of which knowledge is true and necessary. Questions should be answered. Yet the reverse occurs. As knowledge grows, certainty declines. More questions are raised than are answered. These new questions then must be answered and the uncertainty must be resolved. Research is believed to be required to do this. The resulting research then creates more questions and uncertainties. It is commonly believed that the most detrimental by-products of research and technology are weapons, pollutants, noise, heat, and longer life. However, the most disasterous by-product may well be uncertainty which simultaneously makes more research necessary and destroys a society's security and philosophy of life.

Search for Competitive Advantage

New knowledge is used to create new products, new processes, new policies, even new industries. The competitive advantage enjoyed by the user of the new knowledge is often substantial and clearly visible. The original knowledge-user wishes to maintain his advantage and others want to acquire it. Therefore, all must do research to maintain or achieve the knowledge advantage that was created by previous research.

This competitive advantage loop operates with respect to government research, particularly in military and space projects, as governments contend for supremacy. It operates in private research as companies compete for economic benefits. And it operates in education as colleges vie for prestige, the best students, and future support.

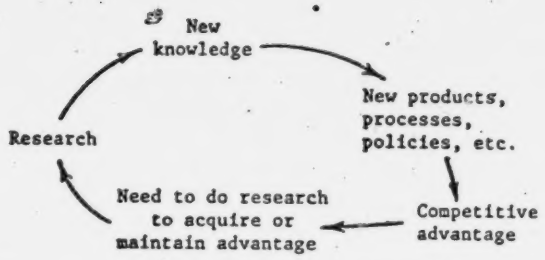

Figure 2. The competitive advantage generation loop.

A Source of Revenue

Research appears to be a desirable activity from a financial point of view when it is paid for by organizations outside the educational system. The contribution to overhead and the support of students and related educational activities provided by such projects eases the impact of rapidly rising costs. In fact, in some places research is done primarily for financial reasons and solvency would be threatened if research activities were curtailed.

Unfortunately, a substantial part of the cost pressure is caused by the research already done and the need to do more. The previous research has created new knowledge which necessitates larger libraries, new equipment and laboratories, computers, etc. Better trained staff people are also needed to teach the new knowledge, to supervise the use of new facilities, and to do future research. Higher quality staff people and expanded facilities are costly, so more research must be done to help support the additional expenses.

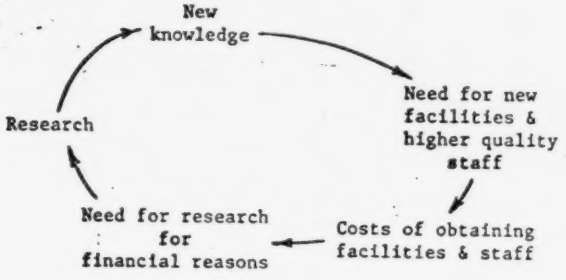
New knowledge
Need for new facilities & higher quality staff
Costs of obtaining facilities & staff
Need for research for financial reasons
Research

Figure 3. Research and financial control loop.

Staff Support

As research becomes a necessary or desirable activity in academic institutions, the need for instructors who can also do research becomes clear. Standards for staff hiring and promotion become dependent on research, as well as teaching proficiency. Unfortunately, teaching and research, as normally practiced, require different sets of skills and attitudes. Few people are highly competent and strongly motivated to do both. Since research skill is easier to measure, has higher prestige value, and pays off sooner, the tendency is to acquire an ever more research-oriented staff.

As the research-oriented teaching staff is assembled, it becomes necessary to provide research for the staff to do. Even if the demand for research work for other purposes were to diminish, the need to generate research to keep researchers busy would still exist. Therefore, the initial research creates a condition (a research-oriented staff) which requires the creation of more research.

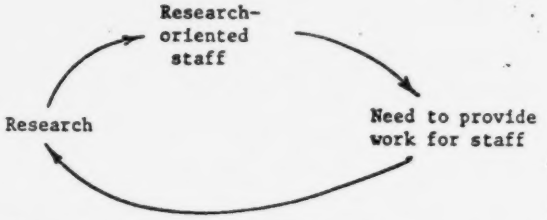

Figure 4. Research-oriented staff generation.

Research Limitations

The above control loops tend to reinforce the expansion of research once it is started. The result is an accelerating growth in research activity and knowledge creation. However, nothing can grow indefinitely without bound and research is no exception. What then might be the eventual constraints on the growth of research? All possible knowledge might be discovered and make research unproductive. However, the mysteries of man and the universe seem endless.

There are some current symptoms of restraint. The congress may soon be inclined to cut research support, if student violence persists. If the violence can be traced in part to the uncertainties arising from the knowledge explosion, this is a built-in regulator of research. An awareness is growing of the undesirable side effects of the knowledge explosion. The fear of pollution, noise, heat, dehumanization, and ecological interference is beginning to have an effect on research funding in some areas. As instructors devote a larger fraction of their time to research, a point is eventually reached where their teaching efficiency begins to decline. Ultimately, the educational character of the institution is threatened. To prevent declining teaching efficiency and research domination, educational administrators will at some time stop the growth of research.

If research creates so many problems and requires such drastic conditions to restrain it, it might seem logical to stop or slow research as a matter of policy. However, in the short run such an action would mean financial disaster for many schools and general staff demoralization. Such is an example of a dilemma faced by many

human feedback systems -- a long run solution (e.g. reduction of research) to major problems that necessitates a short run disadvantage (e.g., elimination of more current revenues than costs). Since humans typically respond to problems only after the symptoms become severe, long run solutions are rarely implemented. A system's reserves which are needed for support during the short run disadvantage have usually been depleted by the crisis and are not available when needed. Therefore, the manager must take short run actions designed to suppress the symptoms of the problems rather than long run actions designed to solve the problems themselves.

Money, Quality and Violence Crises

As research and knowledge grow, the limiting forces resulting from student violence, awareness of knowledge's disadvantages, and research domination of the schools begin to oppose that growth. Meanwhile, the financial condition of the system deteriorates, the perceived quality and relevance of education declines and violence grows. Since all of the problems are interrelated, actions which ease one often aggravate others.

Quality declines as the student-teacher ratio rises. Hiring additional staff would ease the quality problem, but intensify the financial one. Shifting staff time from research to teaching would also reduce the student-teacher ratio, but financial conditions would suffer in the short run and the staff would be displeased. Substantially increased tuitions would ease the financial problems, but hurt the system's scholarly image, intensify the relevance criticisms and perhaps slow the inflow of economically disadvantaged students. All responses to violence from strong authoritarian control through involvement of students in institution affairs and finally to total submission to student demands appear to be ineffective and result in heated criticism.

Financial Decline

Financial deterioration occurs because revenues are not expanded fast enough through moderate tuition and state support increases and acquisition of research contracts to compensate for increases in student body and in costs of staff and facilities. Temporary relief may be observed, if the small fluctuations associated with tuition correction and research funding occur at about the same time. Figures 5 and 6 show the form of the tuition correction and research funding loops.

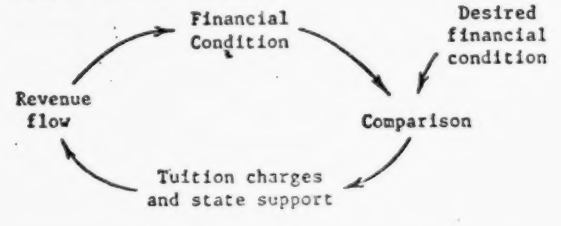

Figure 5. Control of financial condition through tuition & state support increases.

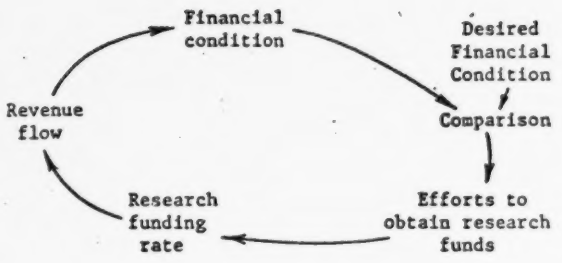

Figure 6. Control of financial condition through research funding.

Similar loops exist to control expenditures. Financial condition influences staff hiring and the amount and timing of facility expansion. However, educational quality deteriorates quite rapidly if the staff is not maintained at about the current proportion with students. Therefore, there is little flexibility in expenditure control actions, except in the timing of facility expansion.

Quality Deterioration

Quality of education as used here refers to the amount and timeliness of what a student learns compared to what he "should" learn given the current state of knowledge and the quality of the teaching staff. The average quantity of knowledge learned during a four year college education has risen steadily over the years. The gap between what is and what should be learned is also rising. As the student-teacher ratio increases, as the research to teaching proportion of staff time rises, as student frustration and violence persist, and as new facilities are postponed, the quality deteriorates.

Such a decline has occurred in some places. As quality falls, doubts about education's relevance are raised. People question the value of an education and the institutions. If the decline proceeds far enough research and academic support may be withdrawn by governments and individuals or governments may exercise greater control. Since rapid change and the resulting financial stringency produce the primary causes of quality deterioration, moderation of either would help to improve quality and the perceived relevance of education.

The Violence Crisis

There is a natural tension between older and younger generations as the younger seeks independence and a feeling of self-worth and accomplishment. However, the universal scope and the severity of today's student violence are believed to arise from the problems of a rapidly changing world.[3] Uncertainty about roles, values and the future; the difference between the ages of biological and social maturity; and the need for constant adaptation to new situations are some of the change-caused conditions leading to frustration.

Humans cannot tolerate high levels of frustration. Violence is one method of relieving it. Others include social withdrawal, drug addiction, and alcoholism.

Two feedback loops influence the interaction between student violence and frustration. A high level of frustration sets the stage for any minor provocation to trigger violence. The violence feeds on itself, attracting more and more people to participate. As the violence persists it dissipates the frustration and declines. Frustration then grows again unless the uncertainties are resolved. Frustration-fueled violence tends to occur in waves. Five to ten years of active destruction will be followed by a similar period of relative calm.

Actions taken by institutions to control violence (police enforcement, negotiation, involvement of students, etc.) may produce small variations in the pattern, but they do not touch the underlying causes or exert great influence.

The Model Structure

The model developed in Figure 7 incorporates the major positive and negative feedback loops which were discussed above. Due to the model's preliminary nature however, not all of the individual loops are incorporated explicitly. Loops not explicitly enumerated are aggregated with other loops of a similar nature. For example, several of the positive loops stimulating further research and knowledge generation are grouped together. In this manner the model retains its dynamic character but allows for simplicity of understanding and demonstration.

The model is composed of five major sectors. Each sector contains important accumulations (blocks in the flow diagram) and rates of flow (pictured as flow values). Connecting these accumulations is the information feedback network through which system conditions are observed and subsequent decisions to alter those conditions are made. The sectors are (1) the student population

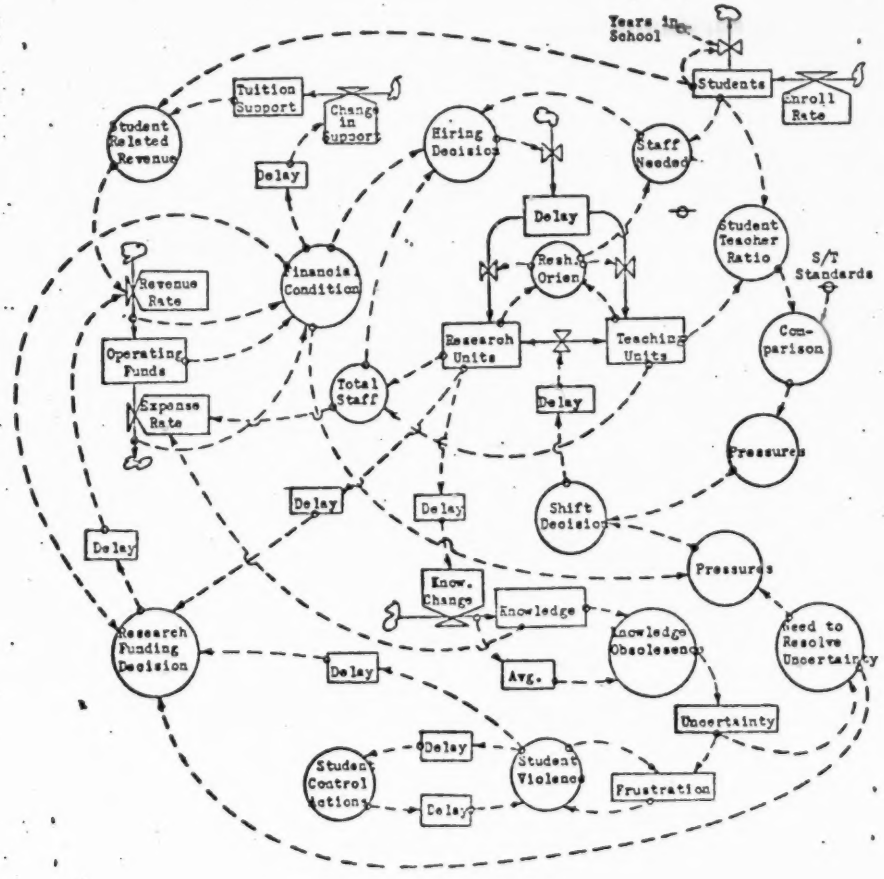

Figure 7. Complete flow diagram for the educational system.

sector, (2) the teaching and research staff sector, (3) the student violence sector, (4) the knowledge accumulation sector, and (5) the financial sector.

The student population sector serves as the independent input to the remainder of the closed system. The teaching and research staff sector attempts to provide an environment where students can receive a quality education. The student violence sector represents the students' feelings of uncertainty and frustration as to the relevance of the knowledge which they are learning. The knowledge sector represents the accumulation of man's knowledge and its rate of change as new research is done and illustrates the consequences in terms of uncertainty and pressures of doing more research. Finally, the financial sector integrates all the system factors which are responsible for generating revenue or creating expenses for the system, and attempts to insure the financial stability of the institution in both the short term and the long term. A more detailed explanation of the individual model sectors and the interrelationships between the sectors will be helpful in understanding the scope and logic for the system structure shown.

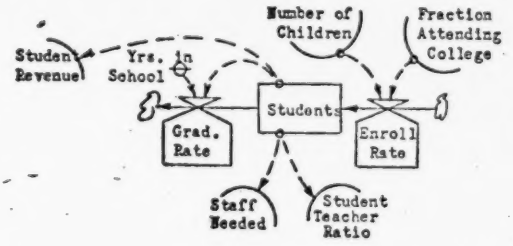

Figure 8. Flow diagram for student sector.

The Student Population Sector

Students are accumulated in the system as a result of an enrollment rate of new students into the system that exceeds the graduation rate from the system (see Figure 8). For purposes of the model, the enrollment rate is given as an independent input which is determined from the increasing number of children coming of college age and the increasing fraction of those children deciding to attend college. The result of these two factors has been an exponential growth of students attending college. The graduation rate from college was taken to be the enrollment rate delayed by four years of study. As the number of students continues to grow, its effects are subsequently felt in other sectors of the model. The staff sector must gear itself up to meet the increased numbers of students while the financial sector must generate additional revenue to pay for the increased staff size and for more facilities to accomodate the increasing numbers of students.

The Teaching and Research Staff Sector

The proportions of staff time for teaching and research must be maintained at a size which (1) will provide sufficient student-teacher interaction time for a quality education and (2) will allow the institution to maintain its research orientation for educational and financial reasons (see Figure 9). Given growing student enrollments then, the staff must be adjusted upwards by the decision to hire more staff (the hiring decision). The number of new staff which must be hired will be based on the difference between the present size of the staff and the staff size desired. The staff size desired or needed will be based on the number of students, the relative composition of the staff (the present research to teacher ratio), and the student to teacher ratios which are desirable. The ultimate decision to hire more staff may ultimately be influenced, however, by financial restrictions which may develop.

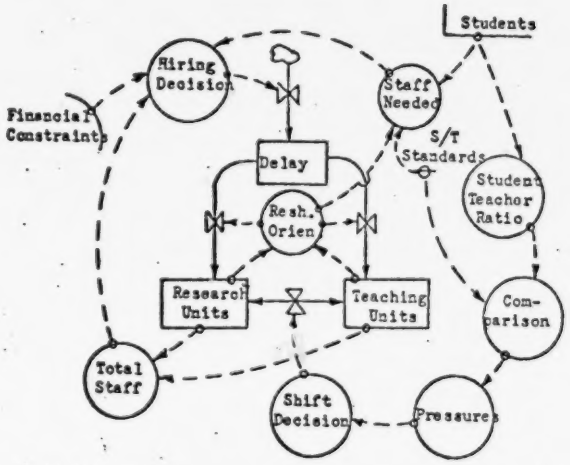

Figure 9. Flow diagram for staff sector.

Not only does the size of the staff change, but the research to teaching composition may change due to the decision to shift staff resources (shift decision). The allocation of the staff between research and teaching may be changed in the short run due to competing pressures between needs to interact with the students more closely and needs to do research to relieve financial pressures and to resolve the uncertainty concerning educational relevance. The pressure which favors the increasing allocation of staff to teaching activities is the decreasing quality of education as represented by the actual student-teacher ratio growing larger than that considered desirable for quality instruction.

Student Violence Sector

Student violence results from the accumulation of frustration created by the uncertainty of the future and the student's inability to understand the rapidly changing environment around him (see Figure 10). Eventually frustration builds to

a level where an emotionally charged atmosphere exists. This is a precondition for violence. When a suitable stimulus occurs, violence erupts. The physical manifestation of the violence after a delay releases some of the pent up frustration and in turn, eventually reduces student violence. Thus the negative feedback structure results in frustration building at a rate dependent on the amount of uncertainty and to a level which finally results in violence. The violence in turn eventually releases much of the frustration which initially created the violence.

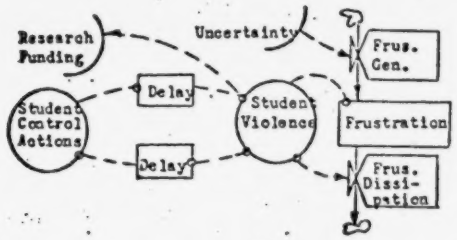

Figure 10. Flow diagram for violence sector.

The precipitation of violence can be postponed but not eliminated by administrative concessions to student demands. However, at some point, the demands can no longer be met, and student violence can no longer be held in check. The violence which subsequently occurs may be even more severe than the violence would have been given no control actions at all.

The Knowledge Sector

Knowledge represents the accumulation of man's experiences, observations, and methodologies of describing and understanding these experiences and observations. Changes in the knowledge base most often result from the conscientious search for new knowledge through research. Actual changes in the knowledge which are eventually integrated into the knowledge base are most likely proportional to the total research effort and lag somewhat behind the research effort due to discovery delays (see Figure 11).

As the amount of new knowledge increases in relation to old knowledge, the old knowledge becomes obsolete. A delay can therefore be associated with how long it will be before knowledge which one could learn in school becomes obsolete. In fact the present span of a technical education has recently been estimated at only seven years -- mainly due to the rapid increase and change in technological knowledge. As the life span of an education decreases (the obsolescence problem) uncertainty about the future increases. The result of the increase in uncertainty has been represented as two-fold. First, the uncertainty generates frustration for the student as discussed previously and secondly, creates pressures on the faculty to do research in order to find out just which knowledge will be important in the future. If this knowledge were known, it could then form the basis for present course materials. Logic would suggest that uncertainty would be reduced since the correct knowledge of the future is being transmitted.

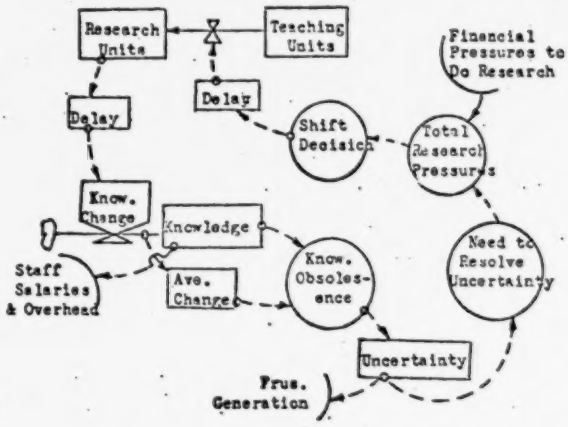

Figure 11. Knowledge sector flow diagram.

At the same time that increasing research is creating an accelerating change in knowledge, the knowledge base itself is exploding. The doubling rate for knowledge on the printed page has recently been estimated at 12 to 15 years. The resulting mass of knowledge has necessitated increased specialization and more lengthy education of future teachers and necessitated increased faculty time which must be committed to merely keeping up with the knowledge in his area. These forces have combined to pressure staff salaries upward as well as pressure related overhead rates per staff member higher. The result has been that staff salaries and overhead support per staff member has grown exponentially as has the knowledge base. This has intensified problems in the financial sector.

The Financial Sector

One measure of financial conditions for the educational system is the relationship of operating funds available and necessary to pay current staff salaries and overhead costs (see Figure 12). Operating funds must be available which will pay these bills for a certain future time span in order to provide the institution with financial liquidity. If the operating funds fall below their desired value based on the current magnitude of average expenses, pressures to either generate additional revenues or cut back current expenses or both are experienced.

In such cases, additional revenue can be sought from two primary places -- research monies (an expedient method of acquiring funds without creating hardships on the students or student-related revenues in the form of higher tuitions

(a socially undesirable alternative which sometimes involves long delays in legislative approval) and higher per student support by the state.

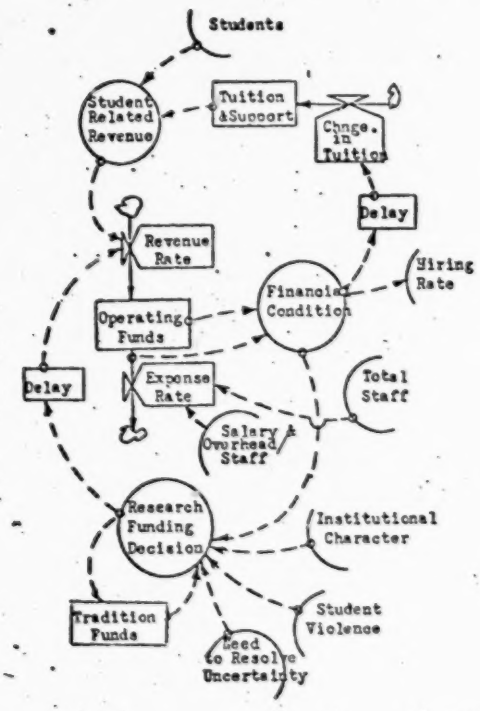

Figure 12. Financial sector flow diagram.

The amount of research monies available from governmental grants, foundations, and gifts are dependent on numerous other conditions which exist at any time in the system. The policy for funds eventually granted (the research funding decision) during any period of time was formulated to be based on the funds traditionally granted adjusted either upward or downward based on other conditions existing in the entire system. Factors which combine to increase the funding level are the need to do research to resolve uncertainty, the financial condition of the institution, and the amount of funds necessary to occupy the research staff employed. Factors which tend to decrease the funds that are granted are student violence and the research nature of the institution. That is, some funds are granted for the sole purpose of aiding the institution in its educational mission. When the institutions begin to demonstrate that they are essentially research organizations instead, additional support based on previous assumptions can no longer be justified.

Performance of the Model

An equation representing each variable in the flow diagram of Figure 7 was written. Then the time history of the model was simulated on the Burroughs B-5500 digital computer at the Rich Electronic Computer Center, Georgia Institute of Technology, using the DYNAMO program language.[8] The resulting performance patterns helped to verify the structure of the model and allowed initial exploration of the multiple feedback loops and decision points in the model. The results have been a preliminary understanding of this complex system and the implications of existing policies on the overall behavior of the educational system.

The plotted simulation in Figure 13 illustrates the model performance for the information feedback structure described above. Included in that structure are formalized policies and decision rules which attempt to describe the present day controlling policies, decisions, and pressures in the educational system. One important variable from each model sector and one supplementary composite variable (quality of education) are plotted on the computer printout from the base time of 1950 through the year 2000. The scales, trends, and phasing of the different variables in the feedback structure seem to be accurate enough for purposes of a first examination of the educational problems mentioned earlier.

The simulation printout illustrates the time history of (1) students, (2) fraction of staff doing research, (3) knowledge, (4) student violence, (5) a measure of financial conditions, and (6) quality of education. The first five variables have each been selected as illustrative of the performance in its respective sector, while the last is a composite of factors affecting educational quality. These factors are the fraction of staff that is research-oriented, the student-teacher ratio, and student violence.

The variables interact through time. Decisions are made to correct conditions, so the state of the system changes. Different patterns of variation are, thereby, created in each variable throughout the fifty year simulation period. Knowledge, students, fraction of staff doing research, and related variables rise consistently. Student violence and its associated variables occur in waves. Measures of performance such as financial condition, quality of instruction, and perceived relevance of education trend downward with occasional temporary recovery periods. As the performance measures deteriorate a point will eventually be reached when the educational system as we know it and as it is represented here will disintegrate or be reorganized. Perhaps, chaos will result. More likely the government will take over. In any case the system will cease to operate as it does now. No attempt has been made to predict what that point will be.

The Growth Variables

The accumulation type variables in the system (e.g., staff, students, knowledge, operating funds) grow consistently through time. Two positive feedback loops generate this growth. The population increase loop is one that is not explicitly included in the model. However, its influence is introduced through the growing input

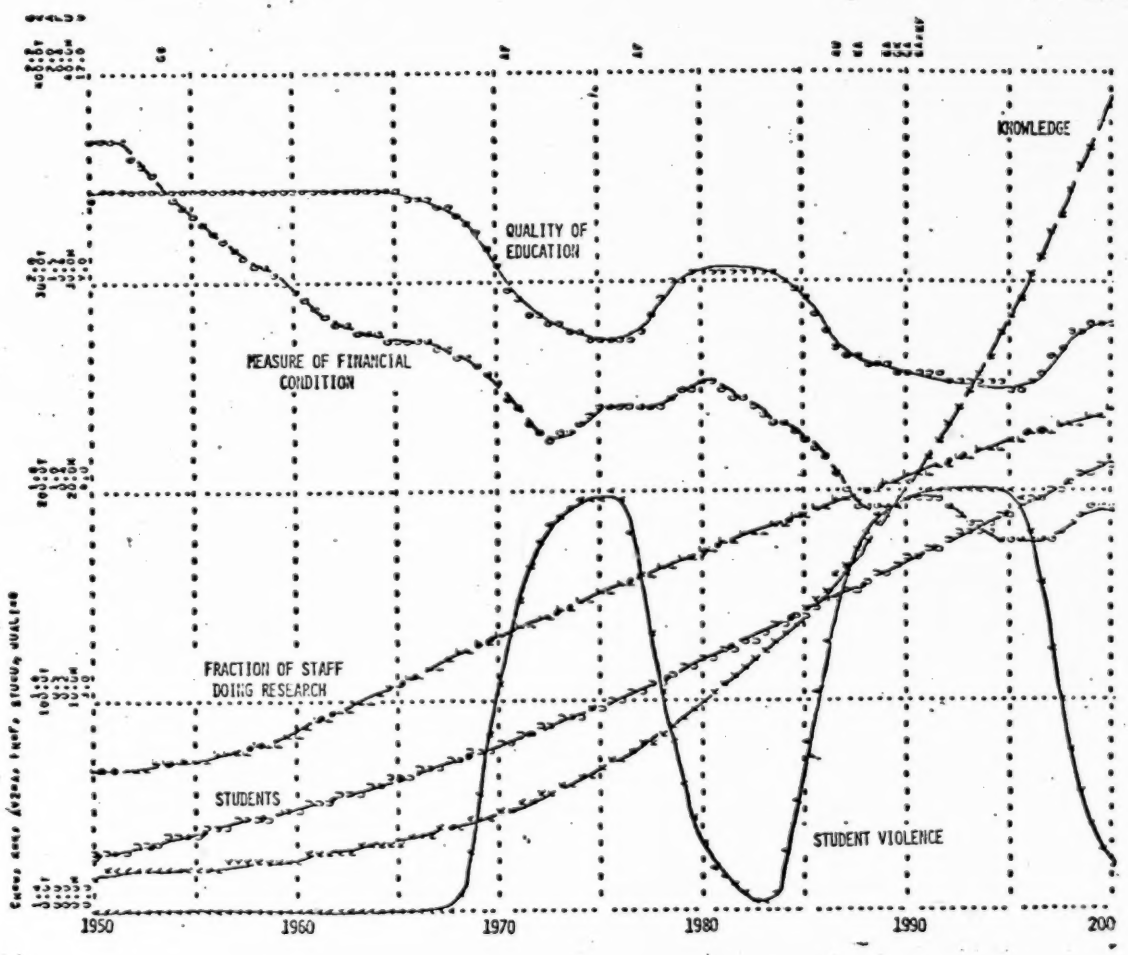

Figure 13. Time history of the educational system.

Students, knowledge, financial condition, quality, student violence, and research fraction of staff time are shown.

of students. The other is not a single loop. It is rather the set of loops that create growing research and knowledge. As students increase, staff must follow. As knowledge increases, costs increase, more operating funds are needed and somehow acquired, the fraction of the population that enters college rises, and tuitions must be raised. While the absolute value of these variables grows, the relationships between them that measure the success of the system may decline.

Declining Effectiveness and Liquidity

When the decisions that keep staff and facilities in balance with students lag or cannot be fully financed, then pressure is exerted on quality of instruction. If the tuition raises and research funding that keep revenues ahead of costs are insufficient, then pressure is exerted on financial condition. If knowledge expands rapidly, educational obsolescence is rapid and education's relevance is questioned. Costs also rise rapidly and threaten solvency if the staff's interest shifts or is diverted from teaching to research, and quality of instruction suffers. These are the forces that produce downward trends in quality and finances.

While on the average through time the corrective actions may be insufficient, there will be times when corrections are strong enough and coincident enough to produce temporary reversals in the downward trend. Such recoveries are seen in the quality and financial condition plots in Figure 13. However, they provide only temporary relief.

Violence Cycles

Student violence occurs in cycles in the plot in Figure 13. Frustration must have time to build up before violence is likely. Once violence

starts, other students at other schools try it also. Violence will grow until the frustration has been sufficiently reduced on a wide enough scale, so that new agitators are no longer encouraged. A decline in violence for a period of time permits frustration to return and a new violence cycle begins.

A Tentative Solution

This research has just started. The model has not been adequately verified or explored. Consequently, defensible recommendations cannot yet be made. However, some conclusions can be drawn from an understanding of this model which may serve as examples of how an industrial dynamics analysis can be used in policy and system structure reformulation.

There seem to be three points in the educational system model that are critical in controlling its behavior. These are the inadequate revenue generating loops, the reinforcing research loops, and the frustration violence mechanism. Since the educational system alone is under consideration, the population growth loop will not be included in the recommendations. It is assumed that use of the educational system (not necessarily in the current four year college format) will continue to increase.

Financial Stability

Unless a strong financial condition is maintained, independent of research funding, pressures are created which create a systematic quality deterioration, research expansion, and relevance decline. While some help might be provided by efficiency of teaching improvement and long run reduced research, sufficient reliable control can only be exercised through tuition and student charges. There are social pressures for universal, low-tuition higher education. But it is possible that students who must pay full costs learn faster and retain longer than those who pay little. Unmotivated students would not enter the system. The new long-term income sharing repayment plans may provide a way for anyone to obtain an education, if he wants it badly enough. Therefore, the first suggestion is: Colleges should charge students full cost.

Research Redirection and Violence Control

The continued expansion of research and knowledge causes many problems. It also creates advantages that insure that the expansion will continue, even if schools were to stop all research. But education cannot stop research because in the short run the system is financially and psychologically dependent on it. A possible solution is for the research fraction to be frozen at the current level and for the subject of research to be changed. Instead of searching for new knowledge, two other types of research are needed. The first type is knowledge consolidation, coordination, simplification, and organization. The second is research to discover the ways in which individual and social development occur and to use this knowledge in the design of a variety of educational experiences appropriate to the different kinds of development.

Today's world is changing rapidly. It is likely that tomorrow's world will also be dynamic. The individual cannot adapt and achieve in that kind of environment if he has the attitudes and knowledge communicated in today's schools. These are based on a static world. Order, security, obedience, hard work, and institutional control are the goals. In a changing world the required knowledge and attitudes enable the individual to constantly (from birth to death) re-educate himself and prepare him to live with constant adaptation, disorganization, creative work and leisure, and future uncertainty. If the uncertainty which causes frustration cannot be eliminated because it is a natural by-product of a changing world, then a way of life must be found to enable people to handle it without excessive frustration. If a philosophy of life and an appropriate educational system existed for this kind of world, excessive student violence would disappear. The research should attempt to discover such a philosophy and educational system. The plethora of randomly organized and poorly monitored educational experiments now being tried probably will not lead to a coherent understanding of the kinds of educational experiences that different kinds of people need to live in a dynamic world.

The policy consequences of this are to maintain research effort at the current level. The objective of the research should be to consolidate and simplify knowledge (not create more) and to understand individual development patterns, so appropriate educational experiences can be designed to facilitate lifelong, individual self-teaching.

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